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LIQUID CRYSTAL DISPLAY DEVICE AND METHOD OF MANUFACTURING
FOR THE SAME

15 [Abstract]

PROBLEM TO BE SOLVED: To sufficiently prevent occurrence of a defect by
contact of a sealing material before curing and a liquid crystal material and
to substantially prevent an increase of process step burden for restriction
on the selection range of the sealing material and sealing material
20 arrangement in the liquid crystal display device and the method of
manufacturing for the same which include a process for arranging the liquid
crystal material on any substrate prior to the combination of an array
substrate and the counter substrate.

SOLUTION: An array substrate 1 is provided thereon with spacer projections

25 15 and simultaneously the points enclosing pixel regions 3 are provided with

two pieces of parallel fence-like projections 11 and 12 of approximately the same projecting dimensions as those of the spacer projections 15. A counter substrate 2 is provided, thereon, with a piece of fence-like projection 21 which is formed of a material having rubber like elasticity and is slightly
5 larger in the projecting height than that of the spacer projections 15. After the liquid crystal material 4 is dropped to the central part of the pixel regions 3, the array substrate 1 and the counter substrate 2 are combined and are bonded, following which the liquid crystal display panel 10 is coated with a sealing material 5 from its end face side.

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[Claims]

[Claim 1]

A liquid crystal display (LCD) device in which a liquid crystal material is maintained in a gap between first and second substrates and sealed by a sealing material pattern with four columns, wherein at least one first fence-type protrusion is installed over an entire inner circumference of the sealing material pattern on the first substrate and at least one second fence-type protrusion interlocked with the first fence-type protrusion is installed on the second substrate.

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[Claim 2]

The device of claim 1, wherein a plurality of first fence-type protrusions are formed in parallel and at least one of the second fence-type protrusions is inserted in the groove between the first fence-type protrusions.

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[Claim 3]

The device of claim 1 or 2, wherein the first or second fence-type protrusion is made of a rubber with elasticity, and in a state that they are pressed on the first or second substrate, it can be sealed with the liquid crystal material and the sealing material before being hardened.

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[Claim 4]

A method for fabricating an LCD device as recited in claim 4 having:
disposing a sealing material surrounding a pixel region on at least one of

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first and second substrates; disposing a liquid crystal material on the pixel region of at least one of the first and second substrates; attaching the first and second substrates with the liquid crystal material interposed therebetween; and bonding the first and second substrates by hardening the sealing material and at the same time sealing the liquid crystal material, comprising: installing at least one first fence-type protrusion surrounding the pixel region on the first substrate; and installing at least one second fence-type protrusion surrounding the pixel region on the second substrate, wherein the first and second fence-type protrusions are mutually interlocked in the attaching step.

[Claim 5]

The method of claim 4, wherein, in the step of installing the first or second fence-type protrusion, a spacer protrusion for maintaining a gap with a certain dimension between the first and second substrates is simultaneously formed.

[Claim 6]

The method of claim 4, wherein the sealing material disposing step is performed from the section side of the first and second substrates after the attaching process.

[Title of the Invention]

**LIQUID CRYSTAL DISPLAY DEVICE AND METHOD OF MANUFACTURING
FOR THE SAME**

5 **[Detailed description of the Invention]**

[Field of the Invention]

The present invention relates to a liquid crystal display (LCD) device which is completed with a liquid crystal material maintained between a pair of substrates, and its fabrication method, and more particularly, to an active
10 matrix type LCD device capable of displaying high precision image.

[Description of the Prior art]

Recently, with its characteristics of being thin and light and low power consumption, an LCD device is employed as a display device of such as a personal computer, a word processor or a TV set and also as a
15 projection type display device in various fields.

Among them, an active matrix type display device in which a switch device is electrically connected with each pixel electrode is actively studied and developed thanks to its advantages of implementing a good display image without a cross talk among adjacent pixels.

20 A light-transmissive active matrix type LCD device will now be described as an example. The active matrix type LCD device is constructed such that a liquid crystal material is maintained between an array substrate and a counter substrate with an alignment film interposed therebetween. Four edge portions of the liquid crystal material is hermetically closed by a
25 sealing material.

As for the array substrate, a plurality of signal lines and a plurality of scan lines are disposed in a matrix form on a glass substrate, a thin film transistor (TFT) as a switching device is positioned near each crossing of the signal line and the data line, and a pixel electrode made of ITO (Indium Tin Oxide) is connected with each signal line.

As for the counter substrate, a light blocking film in a shape of a matrix for blocking light around the TFT and the pixel electrode is disposed on a glass substrate and a counter electrode made of ITO is disposed. In order to perform color displaying, a color filter layer for allocating red (R), blue (B) and green (G) colors is stacked on each pixel.

The display panel of the LCD device are fabricated through the following first to seventh processes.

First, the array substrate and the counter substrates are fabricated through a processing of forming certain films and patterning them.

Second, spherical spacers spread on the array substrate or on the counter substrate. A thermofusion layer is formed on the surface of the spherical spacers in advance. After the spherical spacers spread, the entire substrate is heated to fix the spacers.

Third, the sealing material is coated along an outer edge of a display pixel region on the array substrate or on the counter substrate. In this case, the sealing material is coated except for a portion where an injection opening is formed. Coating of the sealing material is performed such that a syringe or a dispenser is moved in a manner of drawing one line, or through a screen printing method.

Fourth, after both substrates are attached, the sealing material is

hardened by pressing the both substrates. By doing that, a structure of a cell shape (referred to hereinafter as 'cell') maintaining the liquid crystal material is assembled.

5 Fifth, with the cell, an extra marginal region around a finally obtained display panel is cut out through scribing (such as scribing according to glass cutting).

Sixth, the cell is moved into a vacuum chamber, the interior of the cell is completely vacuumized, and then, liquid crystals are injected through the injection opening. In this case, for example, the portion of the injection
10 opening of the vacuumized cell is dipped in a tub of the liquid crystal material so that liquid crystals can be injected according to a capillary phenomenon or an atmospheric pressure.

Seventh, after the liquid crystal material is completely injected, the injection opening is sealed.

15 Instead of spreading and fixing the spherical spacers, a columnar spacer protrusion can be formed in fabricating the array substrate or the counter substrate (e.g., Japanese Laid Open Publication No. 9-7309 and Japanese Laid Open Publication No. 9-73088).

Thus, the related art fabrication method requires much time from
20 injecting the liquid crystal material, failing to enhance productivity of the LCD device. That is, because the gap between the substrates of the cell (namely, a cell gap) is generally about $5\mu\text{m}$, quite narrow, it takes considerable time to inject the liquid crystal material with viscosity. Substantially, for a general LCD device for a notebook computer, it took tens
25 of hours for liquid crystal injection.

Especially, recently, when fabricating a large-scale LCD device used for liquid crystal monitors or home TVs on increasing demands, the injection time is more lengthened. In addition, in order to enhance optical characteristics of the LCD device, the cell gap is reduced, which, however,
5 cause increase in time required for injection of the liquid crystal material.

Thus, a method for dropping the liquid crystal material at an inner side of the sealing material pattern before the both substrates are attached after the sealing material is completely coated in the fourth process can be considered. Especially, installation of protrusions on a fence along an inner
10 circumference of the sealing material-disposed portion on one substrate has been proposed (Japanese Laid Open Publication No. 6-175140).

[Problems to be solved by the Invention]

However, in such a method, an adhesive used as the sealing material
15 must have a low reactivity and compatibility with the liquid crystal material even before being hardened and must not contaminate the liquid crystal material, so its selection is limited to a quite narrow range.

In addition, in order to completely prevent flowing of the sealing material into the fence-type protrusion, it can consider that coating position
20 and amount of the sealing material are adjusted to maintain quite high precision. But it is not easy to enhance precision beyond a certain level with the sealing material liquid with high viscosity and visco-elasticity. In addition, because the fence-shaped protrusion is installed only on some substrates, although coating precision is enhanced, it is difficult to
25 completely prevent contact between the sealing material before being

hardened and the liquid crystal material.

In order to solve the problem, the present invention is to provide an LCD device and its fabrication method including a process of disposing a liquid crystal material on one substrate before a pair of substrates are attached, capable of preventing generation of degradation caused by contact between a sealing material before being hardened and the liquid crystal material and almost preventing limitation with respect to selection of a sealing material material and an increase in a process burden for disposing the sealing material.

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[Means for solving the problem]

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, there is provided an LCD device as recited in claim 1 in which a liquid crystal material is maintained in a gap between first and second substrates and sealed along four edge portions by a sealing material pattern, wherein at least one first fence-type protrusion is installed over an entire inner circumference of the sealing material pattern on the first substrate and at least one second fence-type protrusion interlocked with the first fence-type protrusion is installed on the second substrate.

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With such construction, generation of degradation caused by contact between the sealing material before being hardened and the liquid crystal material can be prevented and there is no limitation with respect to selection range of the sealing material material or burden of a process for disposing the sealing material.

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An LCD device as recited in claim 3, wherein the first or second fence-type protrusion is made of a rubber with elasticity, and in a state that they are pressed on the first or second substrate, it can be sealed with the liquid crystal material and the sealing material before being hardened.

5 With such a construction, contact between the liquid crystal material and the sealing material before being hardened can be sufficiently prevented.

A method for fabricating an LCD device as recited in claim 4 having:
disposing a sealing material surrounding a pixel region on at least one of first and second substrates; disposing a liquid crystal material on the pixel
10 region of at least one of the first and second substrates; attaching the first and second substrates with the liquid crystal material interposed therebetween; and bonding the first and second substrates by hardening the sealing material and at the same time sealing the liquid crystal material, comprising: installing at least one first fence-type protrusion surrounding
15 the pixel region on the first substrate; and installing at least one second fence-type protrusion surrounding the pixel region on the second substrate, wherein the first and second fence-type protrusions are mutually interlocked in the attaching step.

The method for fabricating the LCD device as recited in claim 6,
20 wherein the sealing material disposing step is performed from the section side of the first and second substrates after the attaching process.

With such a construction, burden for the sealing material coating position and precision required for the coating amount of the sealing material can be considerably reduced, and thus, a process burden for
25 coating the sealing material can be reduced.

[Embodiment of the invention]

The embodiment of the present invention will now be described with reference to Figures 1 to 4.

5 Figure 1 is a schematic view showing a display panel of the LCD device in accordance with the present invention. A liquid crystal material is omitted.

10 Inner and outer fence-type protrusions 11 and 12 are formed in parallel at an edge portion of the first array substrate. The inner side is a pixel region 3 in which pixels are arranged in a matrix form. As shown, there is no joint in the inner and outer fence-type protrusions 11 and 12 and a groove 13 is formed between the inner and outer fence-type protrusions 11 and 12. The inner and outer fence-type protrusions 11 and 12 are formed in a tapered shape, the groove 13 is formed to be wedge-shaped in an upward
15 direction.

20 The inner and outer fence-type protrusions 11 and 12 are made of the same material as spacer protrusions 15 arranged with a certain distribution density in the pixel region 3 and formed simultaneously with the spacer protrusions 15. For example, like formation of a resistor pattern, they are formed by an acrylic resin and fabricated through an exposing and developing process. Thus, the protrusion dimension of the fence-type protrusions 11 and 12 is the same as the spacer protrusions on the array substrate, and thus, the same as a space (namely, cell gap) between the array substrate and the counter substrate. In detail, because a film-formation
25 pattern with a thickness such as a scan line or the like is disposed at the

portion of the spacer protrusion 15, it is preferred that such a film-formation pattern as the spacer protrusion is installed at the portion where the fence-type protrusion is installed. In this case, the sum of the thickness of the film-formation pattern such as the scan line and the height of the fence-type protrusion is equivalent to the cell gap.

On a counter substrate 2, one fence-type protrusion 21 is installed at a portion corresponding to the groove 13 of the array substrate 1. Like the fence-type protrusion of the array substrate 1, the fence-type protrusion 21 of the counter substrate 2 also does not have a joint and surrounds the pixel region 3 along the four edge portions. The fence-type protrusion 21 of the counter substrate 2 is made of a rubber material with elasticity and made of a material that can be sealed with the sealing material and the liquid crystal material when it is pressed on the surface of the counter substrate 2. For example, it can be made of a material of a vinyl silicon rubber group used for a packing rubber.

The protrusion dimension of the fence-type protrusion 21 of the counter substrate 2 is a little larger than the spacer protrusion 15. Namely, it is set to have a bit larger dimension than the depth dimension of the groove 13. In addition, the fence-type protrusion 21 has a tapered-shape section and a little narrower width of a front end portion and bottom portion than the width corresponding to the groove 13.

When the counter substrate 2 and the array substrate 1 are attached, the fence-type protrusion 21 of the counter substrate 2 is interlocked with the fence-type protrusions 11 and 12 of the array substrate 1, whereby mutual position-misalignment in the direction of the substrate can be

prevented.

The process of assembling a display panel 10 from the array substrate 1 and the counter substrate 2 will now be described with reference to Figures 2 to 5.

5 First, the array substrate 1 and the counter substrate 2 are introduced into a vacuum chamber and sufficiently vacuumized, and then, as shown in Figure 2, an liquid crystal material 4, from which air bubbles have been completely removed, measured with high precision is dropped at a substantially central portion of the pixel region 3 on the array substrate 1.

10 Next, as shown in Figure 3, the fence-type protrusion 21 of the counter substrate 2 is positioned in the groove 13 and the array substrate 1 and the counter substrate 2 are pressed to be combined. In this case, the liquid crystal material 4 can be enlarged toward the circumferential portion and spread over the entire region of the inner side of the inner fence-type
15 protrusion 11. Namely, at a point when the pressing is completed, there is no gap in the display panel 10 formed with the array substrate 1 and the counter substrate 2. In addition, since the liquid crystal material 4 is precisely measured and dropped, the cell gap is not increased more than a value defined by the spacer protrusion 15, and in addition, when the array
20 substrate 1 and the counter substrate 2 are attached, the fence-type protrusions 11, 12 and 21 are not deviated outwardly from their engaged (interlocked) portions.

Subsequently, a sealing material 5 is coated at the gap portion between the counter substrate 2 and the array substrate 1 along each
25 section of the counter substrate 2 over the entire circumference in the

vacuum chamber. At the side of the array substrate 1 where a connection circumferential portion 16 connected with a TCP is disposed, the sealing material 5 is coated between an edge of the counter substrate 2 and the array substrate 1. In addition, at other side, the sealing material 5 is coated
5 along the section of the cell, namely, along the section of the display panel 10 during fabrication.

And then, when the display panel 10 in the course of fabrication is returned to an atmospheric pressure, a gap between the sealing material 5 before being hardened and the outer fence-type protrusion 12 disappears
10 according to working of the atmospheric pressure. Thereafter, the sealing material 4 is sufficiently hardened to bond the array substrate 1 and the counter substrate 2 and then the interior of the display panel 10 is completely sealed against outer air. The sealing material 4 is hardened by heating or by irradiating ultraviolet rays or through their combination. In this
15 manner, the display panel 10 of the LCD device is completely fabricated.

In the above embodiment, even when the liquid crystal material 4 is disposed before the array substrate 1 and the counter substrate 2 are attached, contact between the liquid crystal material 4 and the sealing material 5 before being hardened can be prevented, so that the liquid crystal
20 material 4 cannot be contaminated and thus a selection range of the sealing material 4 can be extended. In detail, for example, because the liquid crystal material and the sealing material can be completely separated, a hardening resin which has quick dry characteristics so as to be quickly hardened in spite of its high reactivity or compatibility can be selected. As a result, time
25 to be taken for hardening the sealing material can be shortened and the

process of assembling the liquid crystal cell can be also reduced.

As for the fabrication process of the array substrate 1 and the counter substrate 2, only the process of installing the fence-type protrusion 21 on the counter substrate 2 is added. Since the fence-type protrusions 11 and 21 are formed on the array substrate 1 simultaneously when the spacer protrusions 15 are formed, a process burden in fabrication of the array substrate 1 can be reduced.

In particular, the fence-type protrusions 11, 12 and 21 of the array substrate 1 and the counter substrate 2 are formed through a patterning process performed on the substrates, they can be formed to be accurately aligned with other patterns. By suitably adjusting the array substrate 1 and the counter substrate 2, the fence-type protrusion 21 of the counter substrate 2 can be precisely inserted into the groove 13 of the array substrate 1. In this case, since the fence-type protrusions 11, 12 and 21 are formed in the tapered shape, a position-adjustment margin for interlocking them can have a large value.

For example, as for the fence-type protrusions 11, 12 and 21 each with the trapezoid-shaped section, their bottom width can be 0.3mm and the width of the protruded section of them can be 0.2mm, and accordingly, the width of both slope regions becomes 0.05mm (namely, $(0.3-0.2)\text{mm} \div 2 = 0.05\text{mm}$). Thus, the position adjustment margin of the fence-type protrusions which contact with each other at their slope side is 0.1, which is a considerably large value.

In other words, in case where a color filter layer and a black matrix are formed on the array substrate and the array substrate and the counter

substrate do not need to be aligned with high precision, position adjustment of the counter substrate 2 with the array substrate 1 is sufficient by 0.1mm precision. Accordingly, because the position adjustment precision does not need to be high, a process time required for position adjustment can be shortened. In case where a pattern required for position adjustment is formed on the counter substrate, a required position adjustment precision is about 6 μ .

In the above-described embodiment, the two fence-type protrusions are formed on the array substrate 1 and one fence-type protrusion is formed on the counter substrate 2. In this respect, however, more fence-type protrusions can be formed and mutually interlocked. For example, two fence-type protrusions can be installed respectively on the array and counter substrates, or three fence-type protrusion can be installed on the array substrate while two fence-type protrusions can be installed on the counter substrate 2.

In addition, in the above-described embodiment, after the array substrate 1 and the counter substrate 2 are attached, the sealing material 5 are coated from the section side, but the sealing material 5 can be coated on one of the substrates. Especially, by installing multiple fence-type protrusions on the substrate where the sealing material 5 is coated, flowing of the sealing material 5 toward the inner side of the fence-type protrusion can be prevented even if precision with respect to a coating position and a coating amount of the sealing material 5 is not high.

Moreover, even when one fence-type protrusion is installed on both the array substrate 1 and the counter substrate 2, the same basic effect of

the present invention can be attained. Namely, in this respect, if the fence-type protrusion on one substrate can be made of a rubber material with elasticity and has a larger protrusion dimension than the cell gap, installation of one fence-type protrusion on both substrates leads to almost
5 the same effect.

Furthermore, as for the process of installing the fence-type protrusion, it can be patterned following a general coating such as a spin coating, and in addition, for example, it can be patterned after a resin layer with a uniform thickness is formed through a beta printing or through
10 transferring from a patterned film.

[Effect of the invention]

As so far described, generation of degradation caused by contact between the sealing material before being hardened and the liquid crystal
15 material can be prevented, the selection range of the sealing material material is not limited, and the burden of process for installing the sealing material can be reduced.

[Description of drawings]

20 Figure 1 is a schematic exploded sectional perspective view showing a display panel of an LCD device in accordance with the present invention;

Figure 2 is a vertical sectional view showing a liquid crystal dropping process in a fabrication method of the LCD device in accordance with the present invention;

25 Figure 3 is a vertical sectional view showing a process of attaching

both substrates in the fabrication method of the LCD device in accordance with the present invention;

Figure 4 is a vertical sectional view showing a state that a sealing material is coated in a vacuum state in the fabrication method of the LCD device in accordance with the present invention; and

Figure 5 is a vertical sectional view showing a state that the substrates are returned to an atmospheric pressure after the sealing material is coated in the fabrication method of the LCD device in accordance with the present invention.